Customer No.: 31561
Docket No.: 10958-US-PA
Application No.: 10/604,651

REMARKS

Present Status of the Application

The Office Action rejected claims 1 and 20-28 under 35 U.S.C. 103(a), as being unpatentable over Takayama (U.S. 6,610,142) in view of Koda (US 5,563,093). The Office Action also rejected claims 2, 4, 7-11, 13 and 16-19 under 35 U.S.C. 103(a) as being unpatentable over Takayama (U.S. 6,610,142) and Koda (US 5,563,093) and further in view of Jen (JJAP Part 2: Letters 1991, 33(7B), L997-L979) and Luan (Jour. Of Appl. Phys. 1990, 68(7), 3445-3450).

Applicants have amended claims 1 and 10 and newly added claims 42-46 to more clearly define the present invention. The limitation added in claims 1 and 10 are shown in Figures 1B-1C. Figures 1B-1C show there is no film layer formed on the surface of the amorphous layer after the plasma treatment is performed. The limitations of the newly added claim 42-46 are described in paragraph [0018]-[0028] of the specification. Therefore, no new matter is entered. After entry of the foregoing amendments, claims 1-2, 4, 7-11, 13, 16-28 and 42-46 remain pending in the present application, and reconsideration of those claims is respectfully requested.

Discussion of claim objections

Claims 1-2, 4, 7-11, 13 and 16-28 are objected to because "voltage determining from the plasma treatment" is required to correct. Applicant has amended "voltage determining from the plasma treatment" into "voltage determined by the plasma treatment" in claims 1 and 10 to overcome the objection.

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Rejections of 35 U.S.C 103 (a)

The Office Action rejected claims 1 and 20-28 under 35 U.S.C. 103(a) as being unpatentable over Takayama (U.S. 6,610,142) in view of Koda (US 5,563,093). Applicant respectfully traverses the rejections for at least the reasons set forth below.

> To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations.
>
> The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, not in applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).
>
> "See M.P.E.P. 2143, Latest Revision August 2006".

The present invention is in general related to a method of forming a low temperature polysilicon thin film transistor as claim 1 recites:

Claim 1. A method of forming a low temperature polysilicon thin film transistor, comprising:

forming an amorphous silicon layer over a substrate;

performing a plasma treatment to the amorphous silicon layer, ***wherein the plasma treatment is selected from nitrous oxide (N_2O) plasma, ammonia (NH_3) plasma or hydrogen (H_2) plasma, and there is no film layer formed on the surface of the amorphous silicon layer after the plasma treatment is performed***;

transforming the amorphous silicon layer into a polysilicon layer;

patterning the polysilicon layer to form a plurality of island polysilicon layers;

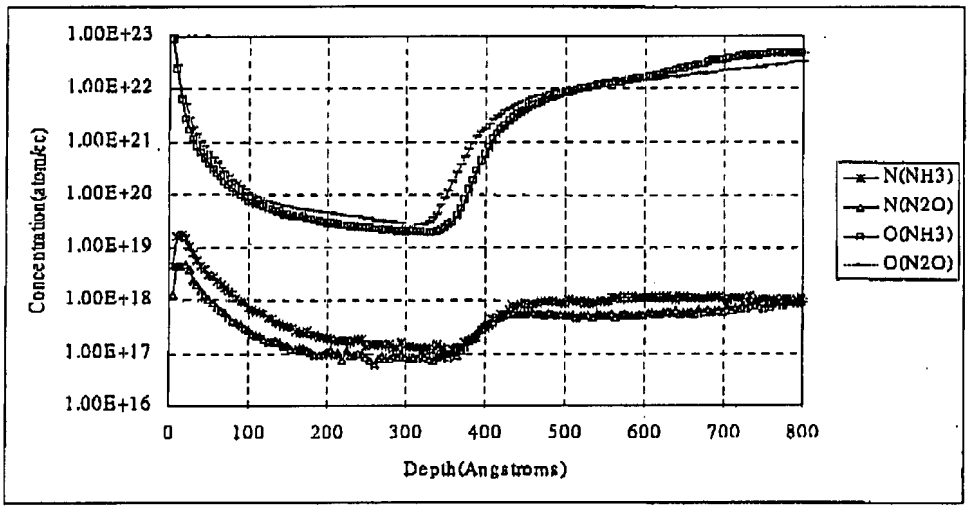
forming a channel region and a doped source/drain region on each side of the channel region in each island polysilicon layer; and

forming a gate over each channel region, wherein the channel region composed of polysilicon has an adjusted threshold voltage determining from the plasma treatment.

The office action stated Tokayama does not disclose performing a plasma treatment to the amorphous silicon layer, wherein the plasma treatment is selected from nitrous oxide plasma, ammonia plasma or hydrogen plasma. Koda discloses forming an amorphous silicon layer 3; pre-treating the amorphous layer such that a surface of the amorphous silicon layer is nitridized to form a silicon nitride layer 53, wherein the pre-treating step is conducted by treating the amorphous silicon layer with nitrogen containing plasma (see Fig. 2, col. 13, lines 1-5). The

Examiner also agrees in the Koda reference, a silicon nitride layer is formed on the surface of the amorphous silicon layer after the pre-treating step is conducted.

However, in claims 1 and 10, there is no film layer formed on the surface of the amorphous silicon layer after the plasma treatment is performed. In the present invention, after the plasma treatment is performed on the surface of the amorphous silicon layer, a plurality of dangling bonds would be formed on the surface of the amorphous silicon layer and nitrogen radicals are implanted into the amorphous silicon layer. In order to proof that in the present invention there is no film layer formed on the surface of the amorphous silicon layer after the plasma treatment is performed, a test of exposing the amorphous silicon layer in the atmosphere is performed. After the amorphous silicon layer is exposed in the atmosphere, the dangling bonds on the surface of the amorphous silicon layer would react with oxygen so as to form a native oxide layer, and thus oxygen and nitrogen can be detected on the surface of the amorphous silicon layer, as shown in the following drawing which is the analysis result of SIMS. That is, because there is no film layer formed on the surface of the amorphous silicon layer after the plasma treatment is performed, oxygen and nitrogen can be detected on the surface of the amorphous silicon layer after the amorphous silicon layer is exposed in the atmosphere. However, in the Koda reference, the wafer is maintained in an ammonia gas at a temperature of 500℃ for 10 minutes to form a silicon nitride layer having a thickness of 5 nm on the amorphous silicon layer, and thus the amorphous silicon layer would not be react with oxygen when the amorphous silicon layer having the silicon nitride layer thereon is exposed in the atmosphere.



In addition, Koda teaches the pre-treating step for the amorphous silicon layer is maintaining the wafer in an ***ammonia gas*** at a temperature of 500℃ for 10 minutes (see col. 13, lines 1-3). Koda does not teach the pre-treating step is selected from ***nitrous oxide (N_2O) plasma, ammonia (NH_3) plasma or hydrogen (H_2) plasma***.

For at least the foregoing reasons, Applicant respectfully submits Koda does not teach performing a plasma treatment to the amorphous silicon layer, wherein the plasma treatment is selected from nitrous oxide plasma, ammonia plasma or hydrogen plasma, and there is no film layer formed on the surface of the amorphous silicon layer after the plasma treatment is performed. Koda cannot cure the deficiencies of Tokayama. Therefore, independent claim 1 is patentable over Tokayama and Koda.

Regarding to claims 20-28, claims 20-28 are dependent claims of claim 10. If independent claim 10 is allowed, its dependent claims 20-28 are also allowed as a matter of law. However, the

office action rejected claim 10 as being unpatentable over Takayama and Koda and further in view of Jen (JJAP Part 2: Letters 1991, 33(7B), L997-L979) and Luan (Jour. Of Appl. Phys. 1990, 68(7), 3445-3450).

The office action rejected claims 2, 4, 7-11, 13, 16-19 under 103(a) as being unpatentable over Takayama and Koda and further in view in view of Jen (JJAP Part 2: Letters 1991, 33(7B), L997-L979) and Luan (Jour. Of Appl. Phys. 1990, 68(7), 3445-3450). Applicant respectfully traverses the rejections for at least the reasons set forth below.

As discussed above, Tokayama and Koda fail to disclose, teach or suggest the amorphous silicon layer is treated by nitrous oxide (N_2O) plasma, ammonia (NH_3) plasma or hydrogen (H_2) plasma, and there is no film layer formed on the surface of the amorphous silicon layer after the plasma treatment is performed. Tokayama and Koda fail to teach or suggest each and every element of claim 1, from which claims 2, 4, 7-9 depend. Lurn and Jen also fail to teach ***the amorphous silicon layer*** is treated by nitrous oxide (N_2O) plasma, ammonia (NH_3) plasma or hydrogen (H_2) plasma, and ***there is no film layer formed on the surface of the amorphous silicon layer after the plasma treatment is performed.*** Lurn and Jen cannot cure the deficiencies of Tokayama and Koda. Therefore, independent claim 1 is patentable over Tokayama, Koda, Lurn and Jen. For at the least the same reasons, its dependent claims 2, 4, 7-9 are also patentable as a matter of law.

Regarding to claims 10-11, 13, 16-19, claim 10 is an independent claim and the others are dependent claims.

Claim 10. A method of forming a low temperature polysilicon thin film transistor, comprising:

providing a substrate;

forming an amorphous silicon layer over the substrate;

performing a plasma treatment to the amorphous silicon layer, ***wherein the plasma treatment is selected from nitrous oxide (N_2O) plasma, ammonia (NH_3) plasma or hydrogen (H_2) plasma, and there is no film layer formed on the surface of the amorphous silicon layer after the plasma treatment is performed***;

performing a laser annealing process to transform the amorphous silicon layer into a polysilicon layer;

patterning the polysilicon layer to form a plurality of island polysilicon layers;

forming a gate insulation layer over the island polysilicon layers;

forming a channel region in each island polysilicon layer and a doped source/drain region on each side to the channel regions; and

forming a gate over the channel regions, wherein the channel region composed of polysilicon has an adjusted threshold voltage determining from the plasma treatment.

As discussed above, Tokayama, Koda, Lurn and Jen fail to teach or suggest the amorphous silicon layer is treated by nitrous oxide (N_2O) plasma, ammonia (NH_3) plasma or hydrogen (H_2) plasma, and there is no film layer formed on the surface of the amorphous silicon layer after the plasma treatment is performed. The four references (Tokayama, Koda, Lurn and Jen) combined do not teach or suggest each and every element in claim 10. Independent claim 10 patently define over the prior art references, and should be allowed. For at least the same reasons, dependent claims 11, 13, 16-19 patently define over the prior art as a matter of law, for at least the reason that these dependent claims contain all features of their respective independent claim.

Newly added claims

Applicant has newly added claims 42-46 in which independent claim 42 is as following:

42. A method of forming a low temperature polysilicon thin film transistor, comprising:

forming an amorphous silicon layer over a substrate;

performing a plasma treatment to the amorphous silicon layer, wherein the plasma treatment is selected from nitrous oxide (N_2O) plasma, ammonia (NH_3) plasma or hydrogen (H_2) plasma;

performing a laser annealing process so as to transform the amorphous silicon layer into a polysilicon layer, wherein the beam of the laser annealing process directly emits into the amorphous layer;

patterning the polysilicon layer to form a plurality of island polysilicon layers;

forming a channel region and a doped source/drain region on each side of the channel region in each island polysilicon layer; and

forming a gate over each channel region, wherein the channel region composed of polysilicon has an adjusted threshold voltage determined by the plasma treatment.

Applicant respectfully submits Koda and Tokayama fail to teach or suggest the performing a laser annealing process so as to transform the amorphous silicon layer into a polysilicon layer, wherein the beam of the laser annealing process directly emits into the amorphous layer. In particular, Koda discloses pre-treating the amorphous layer such that a surface of the amorphous silicon layer is nitridized to form a silicon nitride layer 53, and then the wafer is subjected to a thermal treatment to form a polysilicon film (see col. 13, lines 1-9). Therefore, in the Koda reference, the heat of the thermal treatment is not directly transmitted into the amorphous silicon layer but has to be transmitted through the silicon nitride layer 53. Therefore, independent claim 42 patently define over the prior art references, and should be allowed. For at least the same reasons, dependent claims 43-46 patently define over the prior art as a matter of law.

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CONCLUSION

For at least the foregoing reasons, it is believed that the pending claims are in proper condition for allowance. If the Examiner believes that a telephone conference would expedite the examination of the above-identified patent application, the Examiner is invited to call the undersigned.

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Respectfully submitted,

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